DOCUMENT RESUME

ED 338 054 FL 019 715

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TITLE Distributional Analyses of Parent-Child Conversational Interaction.
PUB DATE Jul 90
NOTE 14p.; In: Papers and Reports on Child Language Development, Number Twenty-nine. California, Stanford University, 1990. p112-124.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Case Studies; Computational Linguistics; *Computer Software; *Interpersonal Communication; Language Acquisition; Language Research; Linguistic Theory; Longitudinal Studies; *Parent Child Relationship; Statistical Analysis
IDENTIFIERS Child Language Data Exchange System

ABSTRACT

A distributional analysis of parent-child conversational interactions for three large longitudinal corpora is reported. First, the potential role of conversational interaction in language learning is examined, and it is argued that certain sources of conversational input provide children with excellent opportunities to advance their linguistic skills. These input sources are characterized according to a typology of interactions between parents and their children, which may be coded and analyzed automatically with a computer program that uses the data and tools of the Child Language Data Exchange System (CHILDES). The program compares pairs of utterances (source and response), encodes them, and tabulates a series of descriptive statistics. The corpora used in the study were from three children, with a combined total of 151,900 coded interactions representing a very large range of communicative interactions. Patterns of interaction for each child-parent dyad are examined as a function of child age. It is concluded that these patterns reveal close relationships between the measured conversational variables of parent and child. Some further analysis is offered. (MSE)

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Distributional Analyses of Parent-Child Conversational Interaction [1]

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The goal of this paper is to present the results of a distributional analysis of parent-child conversational interaction for three large longitudinal corpora. We will briefly examine the potential role of conversational interaction in language learning and argue that certain sources of conversational input provide children with excellent opportunities to advance their linguistic skills. These input sources will be characterized in terms of a typology of interactions between parents and their children that may be coded and analyzed automatically by using a program called CHIP. Following a description of CHIP, we will present the distributional results and discuss their implications.

1. Interactional Sources for Learning

Children may receive many different forms of facilitative input from their parents. Children receive implicit negative feedback concerning their errors:

(1) *SAR: He no bit ya.
*MOT: No # he won't bite ya.

Or parental expansions may provide children with positive examples of correct usage:

(2) *MOT: What happened to your shirt?
*ADA: Got some choc(olate).
*MOT: You got some chocolate on it # didn't you?

Or they may reveal the membership of various lexical items in certain grammatical categories:

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[1] Portions of this article were taken from a doctoral dissertation submitted to Carnegie Mellon University. I would like to thank my committee members Brian MacWhinney, James McClelland, and Patricia Carpenter for their help. A longer version of this paper is also available. CHIP will soon be contributed to CLAN and distributed by CHILDES. Address for correspondence: Jeffrey L. Sokolov, 306 Larsen Hall, Harvard Graduate School of Education, Cambridge, MA 02138, snowjs@hugse1.bitnet.

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(3) *ABE: What you got in your hand?
*FAT: What have I got in my hand?

In Example 3, the parental model reveals to the child that the pairs of *you-I* and *your-my* are grammatically interchangeable. In addition, parental partial repetition of lexical elements from child speech may serve as communicative and cognitive facilitators. Partial repetition may be a communicative facilitator by enhancing topic maintainance and a cognitive facilitator at the same time by reducing memory demands (i.e., lexical access) for the child thereby freeing up more resources for learning.

An interesting comparison would to be examine parental additions to adjacent child speech to determine the rate and pattern of examples provided to the child by the parent and to compare these data with the corresponding values for child deletions of adjacent parental speech. This would provide information about how the amount and pattern of parental input might change as a function of child development. Evidence for this form of contingent input would provide further support for the importance of input in language development. In order to perform this analysis on large corpora of data (over 50,000 utterances), an automatic data coding and analysis program was designed and implemented.

2. The CHIP Framework

CHIP is a computer program for the automatic coding and analysis of parent-child conversational interactions. The program is intended to utilize the data and tools of the Child Language Data Exchange System (CHILDES) as described in MacWhinney (1990; MacWhinney & Snow, 1985). CHIP assumes that data is transcribed according to the CHAT conventions described by MacWhinney (1990). The program was developed to be consistent with the design guidelines (down to the actual code) of the CLAN data analysis programs developed and distributed by CHILDES (MacWhinney, 1990).

CHIP takes as input a computer file containing conversational interaction and adds to it a series of codes describing the similarities and differences between pairs of utterances spoken by different interlocutors. These utterances are called the source and the response utterances. The program is only briefly described in the following sections. For a more detailed and complete description, please consult Sokolov and MacWhinney (in press).

2.1. The CHIP Coding System

The CHIP program looks at pairs of utterances. The first utterance is the "source" utterance and the second utterance is the "response" utterance. CHIP compares the

response utterance to the source utterance and inserts special codes into the child language transcript as a distinct coding tier. In addition, the program tabulates a series of descriptive statistics as it processes a data set (for a description of the summary statistics see Sokolov and MacWhinney, in press).

The following example should provide the reader with a gentle introduction to the coding system. Given the following mother-child interchange:

*CHI: Truck is red.
*MOT: The truck is-'nt red.

The CHIP system would produce the following tiers:

*CHI: Truck is red.
*MOT: The truck is-'nt red.
%adu: $EXA:truck-is-red $ADD:the $MADD:-'nt
$EXPAN $REP = 0.75

The coding tier indicates that the adult response contained an EXAct-match of the continuous string *truck-is-red*, an ADDition of *the*, and a Morphological ADDition of *-'nt*. In addition, since the parent has only added material to the child's utterance, the parental response is also coded as an EXPANsion. Finally, a repetition index is computed for the amount of overlap between the source and response utterances. The repetition index is 0.75 (3 overlapping stems divided by 4 total stems in the largest utterance).

When given a wordlist as input, the program may also code word-class substitutions. For the following example, if the program was given the following list of subject pronouns: *I*, *you*, *we*.

*MOT: We will be go-ing.
*CHI: No, you will be go-ing.

The following coding tiers would be produced:

*MOT: We will be go-ing.
*CHI: No, you will be go-ing.
%chi: $EXA:will-be-go $ADD:no $SUB:you $MEXA:-ing
$REP = 0.80

This coding tier would be described as a continuous EXAct-match of *will-be-go*, an ADDition of *no*, a SUBstitution of *you* for *we*, and finally a Morphological EXAct-match of *-ing*.

2.2. The Automated Coding Process

When CHIP is invoked, it is told by a series of flags who the child and adult participants are and what options to code. CHIP then moves through transcripts of conversational interaction looking for appropriate source-response utterance pairs to code (either child-adult, adult-child, child-child, or adult-adult). When a response utterance is encountered, the program looks backwards (through a window of seven utterances) for the most recent and only the most recent potential source utterance. Only one source utterance is coded for each response utterance. If a source utterance cannot be found within the seven utterance window, the program simply moves forward in the file and starts over. Once a source-response pair has been found, a simple matching procedure is performed. After the matching has been performed, if the amount of overlap is zero or below the minimum specified by the user (the default is zero), then no statistical information is computed and either the code $NO_REP or the code $LO_REP is inserted into the coding tier.

3. A Distributional Analysis of Parent-Child Conversational Interaction

3.1. Method

Three longitudinal corpora from CHILDES (Adam, Sarah, and Kuczaj) were coded and analyzed by the CHIP program. The number and proportion of adult and child operations were tabulated. For the overall analysis, the operations included the addition, deletion, and exact-match of lexical items. For the analysis of word-class differences, the substitution operation was also coded. Parent-child interaction for three different word-classes was examined. The classes included: (1) *modals*; (2) *subject pronouns*; and (3) *nouns*. The list of nouns was generated from the 250 most frequent words in spoken child language as compiled by Hall, Nagy, and Linn (1984). These items were selected to minimize ambiguity. The exact word lists are presented in Appendix A. Non-ambiguous, contracted, forms were also included. For example, the unambiguous form *'ll* was included but not the ambiguous form *'s*. The three corpora of Abe, Adam, and Sarah were divided into six different age sequences: 2;0-2;6, 2;7-3;0, 3;1-3;6, 3;7-4;0, 4;1-4;6, 4;7-5;0. Note that in all tables and figures, each age level will be referenced by the age ending the time period (i.e., 2;0-2;6 will be referred to as 2;6). Both mothers and fathers were included in the analysis but speech from other participants was not coded.

3.2. Amount of Interaction

The goal of this section is to give the reader an idea of the amount of parent-child conversational data that was successfully coded and analyzed by CHIP. Towards this goal, Table 1 lists the absolute number of coded responses for both parent and child for each of the three corpora. The combined total of 151,900 coded interactions is

Table 1: The absolute number of coded responses across age for Abe, Adam, and Sarah.

		2;6	3;0	3;6	4;0	4;6	5;0	Total
Abe	Parent	803	6829	5577	4290	1871	1968	21338
	Child	752	6760	5709	4553	2048	2048	21870
Adam	Parent	2470	4640	5297	4028	2048	1131	19614
	Child	4763	7669	9022	5990	3777	2294	33515
Sarah	Parent	3242	6516	5915	5213	4639	3583	29108
	Child	2721	5719	5213	4351	4966	3485	26455
Total		14751	38133	36733	28425	19349	14509	151900

Table 2: The percentage of overlapping responses across age for Abe, Adam, and Sarah.

		2;6	3;0	3;6	4;0	4;6	5;0
Abe	Parent	0.45	0.40	0.42	0.38	0.37	0.35
	Child	0.41	0.35	0.39	0.36	0.35	0.34
Adam	Parent	0.50	0.48	0.42	0.41	0.37	0.40
	Child	0.28	0.24	0.27	0.29	0.26	0.29
Sarah	Parent	0.26	0.26	0.23	0.24	0.24	0.25
	Child	0.27	0.24	0.16	0.21	0.19	0.19

Table 3: The percentage of repetition within responses across age for Abe, Adam, and Sarah.

		2;6	3;0	3;6	4;0	4;6	5;0
Abe	Parent	0.14	0.11	0.10	0.08	0.08	0.07
	Child	0.15	0.08	0.08	0.08	0.08	0.07
Adam	Parent	0.22	0.22	0.17	0.15	0.12	0.13
	Child	0.10	0.08	0.08	0.08	0.07	0.07
Sarah	Parent	0.12	0.11	0.09	0.09	0.08	0.08
	Child	0.11	0.11	0.06	0.07	0.06	0.05

an extremely large dataset by any measure and could not have been coded manually. In addition, as can be seen in Table 2, a substantial proportion of these responses contain some overlap (at least one word) with their source utterances and are therefore coded for interactional operations. Finally, the percentage of repetition within all responses (including the non-overlapping ones) is listed in Table 3. Interestingly, these general results provide a glimpse of things to come: Both Tables 2 and 3 reveal a developmental trend toward less repetition.

3.3. Patterns of Interaction

In this section, the pattern of interaction for parent and child speakers as a function of child age will be explored. Interactional patterns will be measured by differential usage of the operation types: addition, deletion, and exact-match. The absolute number of words involved in each of the three operation types was transformed into proportions by noting the rate of usage of each operation with respect to the other operations. In other words, if there were thirty additions, fifteen deletions, and five exact-matches for a particular speaker within an age level, the proportional measures for that cell would be 60% additions, 30% deletions, and 10% exact-matches.

Three two-way analyses of variance were performed for the speaker (parent and child) and age (2;0-2;6, 2;7-3;0, 3;1-3;6, 3;7-4;0, 4;1-4;6, and 4;7-5;0) variables. Each analysis was performed with one of the three operation types as the dependent measure. The goal was to determine if there were differences between speakers and whether this difference was a function of the child's age level. Given the young age of the children in the first couple of age groups, we expect to find both speaker and age effects. Parents should produce more additions than children but less deletions. Furthermore, this should change as the child ages by becoming more balanced. With respect to exact-match operations, we would expect only slightly more exact-matches by the parent if only as a strategy to maintain or continue the child's involvement in particular conversations. Finally, as the child's conversational abilities and MLU increase, we might expect to see a slight decrease in the rate of exact-matches due simply to an increase in variety of lexical elements and grammatical devices on the part of the child.

The results for addition operations indicate that these parents and children produce additions at similar rates ($F(1,2) = 1.09, p = 0.4$) that change as the child becomes older ($F(5,10) = 7.55, p < 0.005$) with the rate of parental additions declining and the rate of child additions increasing ($F(5,10) = 33.10, p < 0.001$). The results for deletion operations parallel those for addition. Once again, the overall rate of deletions is similar for these parents and their children ($F(1,2) = 1.2, p = 0.4$) and is changing as the child ages ($F(5,10) = 21.97, p < 0.001$); however, in this case, child deletions decrease with age as the parental ones increase ($F(5,10) = 41.10, p < 0.001$). A glimpse at Figure 1 reveals distributional differences

between parent and child speakers for the addition and deletion operations but this difference is diminished as parents and children become more similar to one another at around age 4;0. This is the source of the significant interaction between the speaker and age factors for these two operations. These two results replicate the findings of Snow (1981) who found that early in their development, children predominately delete material from parental speech but as they grow older, they predominately add material. A close examination of Figure 1 reveals that early developmental change is steeper than later change. This indicates a possible non-linear result. The pattern for exact-matches is different. Once again, parents and children produce exact-matches at about the same rate ($F(1,2) = 1.01, p = 0.4$); however, the rate declines with age ($F(5,10) = 34.342, p < 0.001$) at a similar level for both parents and children ($F(5,10) = 0.67, p = 0.66$). This indicates that both parents and children tend to rely less on exact-matches as the age of child increases.

The next question is whether or not the changes in parental values are related in any way to changes in child values. In order to answer this question, three regression analyses were performed for each parent-child dyad: child additions were correlated with parental deletions, child deletions with parental additions, and child exact-matches with parental exact-matches. These three analyses were the only ones performed because we have both theoretical and empirical grounds to predict positive correlations between both parental additions and child deletions and parental deletions and child additions. The theoretical basis is the fine-tuning hypothesis of parental input which would predict both that parents would add about as much as their children delete and the converse. The empirical basis comes from the statistical results discussed in the previous paragraphs. We would also predict similar rates of exact-match operations because the parent and child cannot copy one another until the child is producing the lexical element and then there should be a tendency for both parent and child to do so just as a simple strategy for support of topic maintenance. There is also a methodological consideration in wishing to avoid the possibility of random significant correlations that may occur with large numbers of correlations.

The results for each of the three variable pairings indicated significant positive correlations for each of the three parent-child dyads (see Appendix B). The high positive correlations between child deletions and parental additions suggest that the proportion of child deletions changes at about the same rate as that of parental additions. We can interpret this as indicating that as long as child speech is incomplete, the parent will be augmenting it.

The high positive correlations between child additions and parental deletions suggest the complement of the previous correlations. As the child's MLU and mastery of grammatical devices increases, there will be more additions. Some of these will be relevant to the conversation, some will not. This increase in materials lends itself almost trivially to routine parental deletes. Interestingly, although the

present analysis does not tell us this, a small number of these parental deletions must be responses to overgeneralizations by the child.[2] The third relation, that of child exact-matches and parental exact-matches, is also one with high positive correlations. In this case, both the child and parental production of exact-matches decreases. The decrease in exact-matches can be understood if we assume that conversations become more complex and varied as the child ages. As a consequence of the expansion in the range of lexical devices used, there is less repetition.

In sum, these contingent patterns represent the input children receive over an extremely large range of communicative situations. The patterns should probably not be viewed as evidence of a conscious strategy on the part of the parent. For the most part, they no doubt represent a tendency on the part of the parent to add material not present in the incomplete child repertoire as part of the normal conversational flow. This will be discussed further in the conclusion to this section. With this many source-response pairs, we know that it is possible to further differentiate conversational interaction based on codes that could only be computed manually. Even so, some further distinctions are possible to compute automatically and attempts will be made to do so in the following section.

3.4. Word-Class Differences

We know from the previous section that there is a strong relationship between parental and child interactional variables. In this section, we are interested in determining whether this relationship changes as a function of word-class. We would expect that it would given differences in acquisitional rates and answerhood requirements. To test this hypothesis, CHIP coded and analyzed the three corpora with respect to three different word-classes (*modals*, *subject pronouns*, and *nouns*). The proportional results are graphed in Figures 2-4.

The overwhelming result is that the contingent relationship between parents and their children in conversational interaction is maintained across word-classes. This is especially true for the two closed-class items. For the modals, there is a steep decrease in parental additions and child deletions as the children become older that levels off around 4;0. There is also an steady increase in child additions and parental deletions that levels off around 4;6. In addition, substitutions begin to play a substantial role in conversational interaction around 3;6. This is no doubt due to the heterogenous nature of modals. Since we know from the child language literature (e.g., Brown, 1973) that there is a clear acquisitional pattern in the acquisition of modals, it is not surprising to find developmental differences in

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[2] To perform this analysis, one could execute a keyword search within a chip-coded transcript for parental deletions of particularly interesting items (e.g., auxiliaries) and then code any overgeneralizations that existed by hand.

Figure 1: General CHIP Analysis

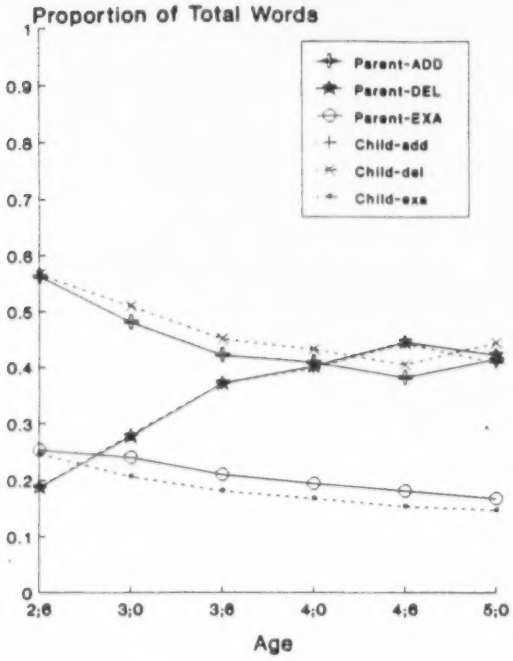


Figure 2: CHIP Analysis of MODALS

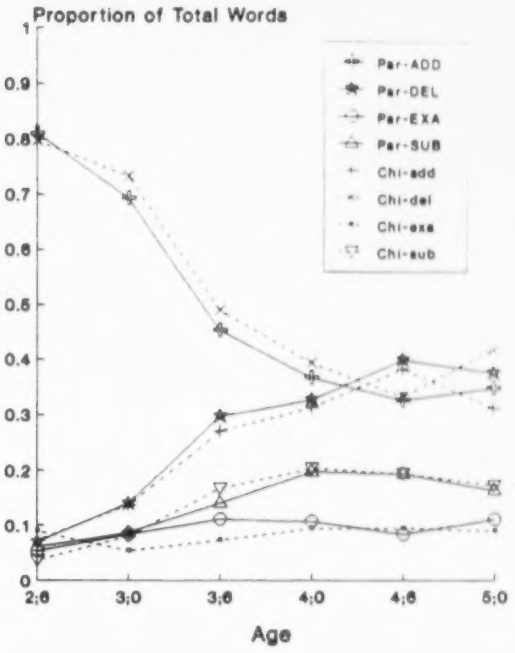


Figure 3: CHIP Analysis of PRONOUNS

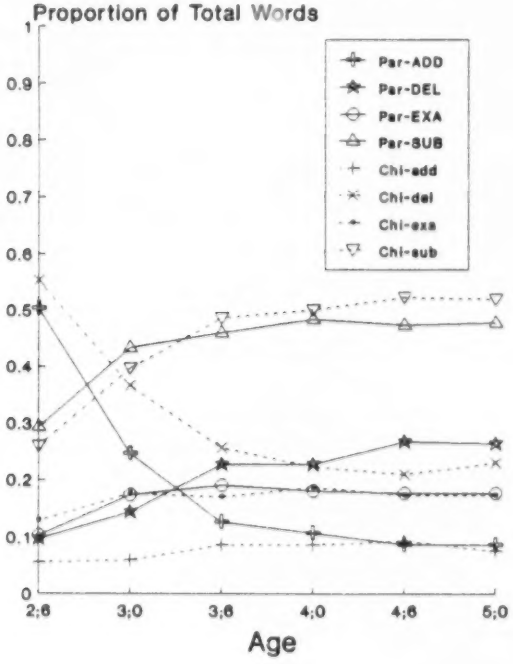
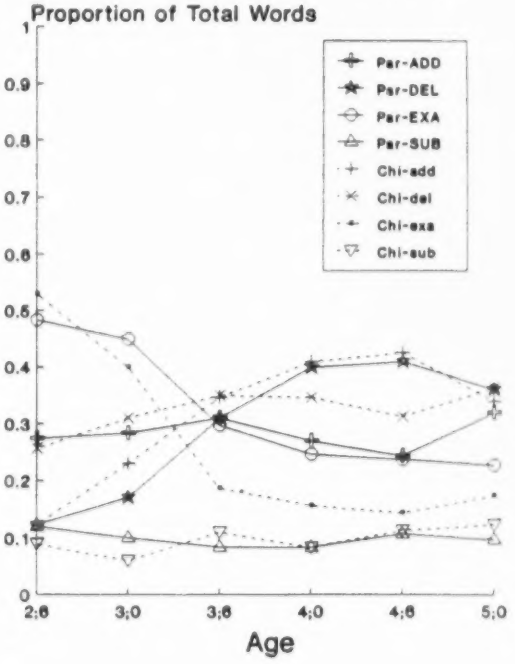


Figure 4: CHIP Analysis of NOUNS



additions and deletions. We can interpret this as indicating that as long as the child is not producing an item, the parent will be providing lots of positive examples of how to use that item in speech. The results for subject pronouns are slightly different: Once the developmental changes for the addition-deletion patterns level off, there is a large increase in substitutions. This is also intuitive since we would expect free substitutions (especially for first and second person pronominals). For the open-class nouns, the patterns exhibit a large proportion of exact-matches early in development that tails off as the children get older.

What exactly is the nature of the differences between word-classes and what could explain these differences? In order to answer this question, it is necessary to discuss the results for groups of word-classes separately. Describing the different interactional patterns for each of the word-classes is largely an expository endeavor; however, explaining the differences requires consideration of several additional issues. For the present discussion, we will briefly explore three classes of concerns: Differing interactional patterns may be due to (1) differing linguistic considerations inherent in each word-class; (2) differing communicative considerations associated with the functional bases of each word-class; and (3) differing rates and patterns of acquisition on the part of the child.

The modals express central notions of tense, aspect, and modality and their position often determines sentential function (i.e., in questions). In addition, children often omit or misuse these items during their acquisition. These general observations are also true, albeit in a different way, of subject pronouns. Pronominal substitution is one of the more central means for expressing person and number in English. Also, substitution is a relatively complex task that children must learn. Since these two closed-class items are central components of English, the parental strategy of adding them to incomplete child utterances is likely to significantly enhance parent-child communication. In contrast, the use of nouns is, by definition, freer than that for the closed-class items and their acquisition also follows a different route. These differences would help to explain the difference in interactional patterns found for the closed-class items as opposed to the open-class one.

Both the results for the full-corpora and word-class analyses indicate highly contingent differences between parent and child speakers as a function of child age and ability. These results are consistent with other recent findings concerning parental input (Hirsh-Pasek et al., 1984; Demetras et al., 1986; Bohannon and Stanowicz, 1988) and continue to suggest that the *no-negative-evidence* claim is, at best, tenuous.

4. Conclusion

The data presented in this article were obtained with the aid of a new research tool: automatic data coding and analysis by computer. Automatic data coding and

analysis programs have many advantages over manual coding. They have the potential to save time and effort *and* to reduce manual coding errors. Importantly, their ease of use greatly facilitates replication. CHIP, an example of such a tool, has provided detailed information concerning the exact nature of parent-child conversational interactions through analyses of over 150,000 utterances. To code and analyze such a large corpus of data would have taken a prohibitive amount of time if performed manually and would have been subject to a large number of coder errors due to the amount of detail involved. In addition, since CHIP not only tabulates quantitative data but also actually inserts codes into the transcripts, it is possible to perform many more analyses on these data. In fact, code insertion provides the best of both worlds allowing the human to direct and focus the computer to search for increasingly detailed patterns.

This section established some basic characteristics of the distributional relationship between parent and child interactional variables. The amount of interaction measured is extremely large and has proven to be extremely reliable. The patterns of interaction reveal close relationships between the parent and child conversational variables that were measured. The most significant result of all is that this relationship remained a strong one across the two closed-class items but not as much for the open-class item. These results indicate that young children hear a very large number of parental responses that include specific lexical additions of closed-class items and that these additions continue to be present in the input until children produce them.

What do these results signify in terms of the fine-tuning hypothesis? Is there evidence that parents purposely fine-tune the level of their speech to their children's developmental status? No, the answer is that these results do not speak to the issue of conscious fine-tuning. The presence of a contingent relationship between parent and child conversational variables should not be taken as an indication that parents are consciously fine-tuning their input. It is much more likely that the patterns represent a general strategy on the part of parents that are communicating with linguistically-immature children to naturally and consistently supply missing elements in contingent speech.

Although the fine-tuning may not be purposeful, it can be argued that the interactional patterns discovered in this section are unique to parent-child interactions. The pattern would obviously not exist for adult-adult speech. The trivial reason for this is that neither adult would be producing telegraphic speech and adult-adult speech is more lexically progressive and less lexically repetitious than parent-child speech. Furthermore even adults speaking to children who are not their own are less likely to provide contingent input (Bohannon & Stanowicz, 1988). This indicates that parent-child conversational interaction has a special quality due to the identity of the participants, and as we have argued with respect to learning, a facilitative one also.

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Appendix A: Word-Lists for the Word-Class Analyses

MODALS: another'll, anybody'll, anyone'll, anything'll, both'll, can, can't, cannot, could, could've, coulda, couldn't, dare, everybody'll, everyone'll, everything'll, he'll, how'll, i'll, it'll, many'll, may, might, mine'll, musn't, must, must've, musta, mustn't, need, nobody'll, none'll, one'll, ought, oughta, shall, she'll, should, shouldda, shouldn't, some'll, somebody'll, someone'll, something'll, that'll, there'll, these'll, they'll, this'll, those'll, we'll, what'll, when'll, where'll, which'll, who'll, whose'll, will, willya, won't, would, woulda, wouldn't, you'll

NOUNS: book, books, boy, boys, butter, car, cars, cat, cats, day, days, den, dens, dinner, dinners, dog, dogs, game, games, girl, girls, home, homes, house, juice, juices, people, piece, pieces, room, rooms, school, schools, shirt, shirts, tape, tapes, thing, things, time, water, way, ways

PRONOUNS: I'd, I'll, I'm, I've, anybody, anybody'd, anyone, anything, couldya, d'you, everybody, everyone, everything, everything's, he, he'd, he'll, he's, I, it, it'd, it'll, it's, naught, no-one, nobody, nobody'd, nobody's, none, nothing, nothing's, one, one's, she, she'd, she'll, she's, somebody, somebody'll, somebody's, someone, someone'll, someone's, something, they, they'd, they'll, they're, they've, we, we'd, we'll, we're, we've, willya, y'all, you, you'd, you'll, you're, you've

Appendix B: Regression Analyses for each Parent-Child Dyad

	Variables	CORR	F(1,4)	Prob (F)
	ChiAdd-ParDel	0.99	496.49	0.000
Abe	ChiDel-ParAdd	0.98	114.51	0.000
	ChiExa-ParExa	0.84	9.69	0.036
	ChiAdd-ParDel	0.99	193.36	0.000
Adam	ChiDel-ParAdd	0.94	32.28	0.005
	ChiExa-ParExa	0.91	18.88	0.012
	ChiAdd-ParDel	0.99	566.24	0.000
Sarah	ChiDel-ParAdd	0.98	115.01	0.000
	ChiExa-ParExa	0.97	63.04	0.001